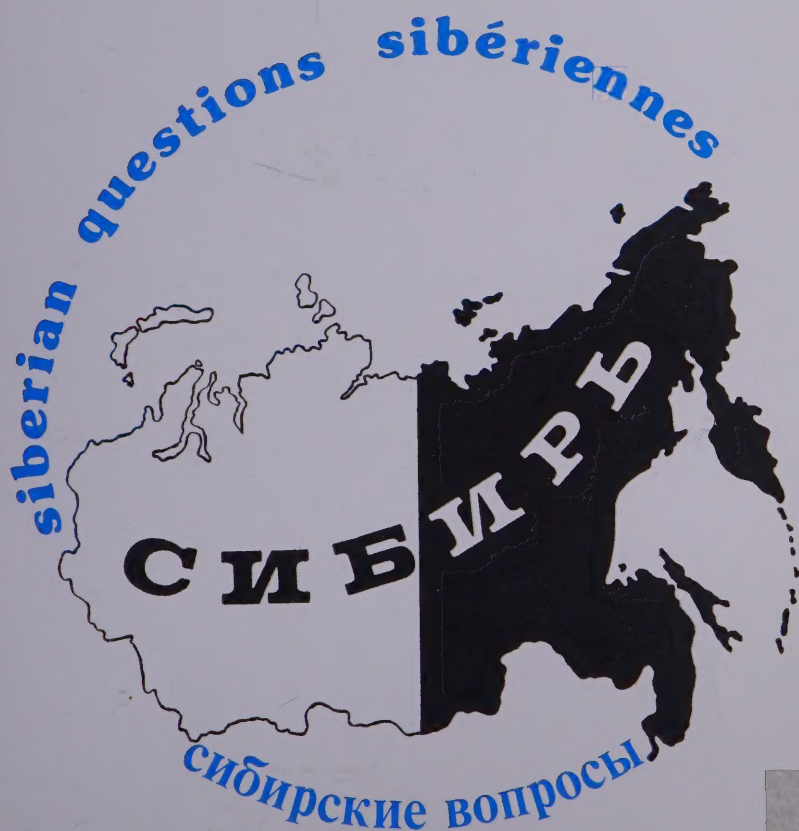


# SIBÉRIE I



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Terence ARMSTRONG

CLIMATE AS A DETERMINING FACTOR IN ECONOMIC DEVELOPMENT:  
THE SIBERIAN CASE

It goes without saying that climate can be a determining factor in economic development, but interest centres on whether there may have been some relatively recent changes in the extent to which this operates. Siberia is a very big place, and it will be helpful if we restrict ourselves to its northern regions, where the climate is harshest. The chief climatic factor we are concerned with is coldness. Northern Siberia, or, to be more exact, the north of the Soviet Far East (I will not henceforth differentiate between them) contains two places which vie with each other for being the coldest in the northern hemisphere: Verkhoyansk and Oymyakon, where the mean January air temperature at the surface is around  $-50^{\circ}\text{C}$  in each case. The cold is severe in all parts of northern Siberia, but in some regions other factors are also significant: low precipitation in the north-east, hot but short summers in regions remote from the sea. The whole area is underlain by continuous permafrost, all rivers freeze seasonally, and the coast is icebound for several months in the year. The question, then, is how much effect does all this have on economic activities of various kinds? What progress has been made in combatting or offsetting these disadvantages? Answers will not be in black and white, because climatic impact is always susceptible to modification by economics. You could grow peaches on the Arctic Circle but it would be expensive. It may be that there are situations in which existing technology could reasonably be applied, but is not. The north Siberian climate as a barrier to communications

(a). Sea transport. The disposition of land and sea is such that the sea offers access to a vast hinterland along the north

*Sibérie I*, Paris, 1984, p. 169-182.

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coast. (The mainly north-flowing river system is complementary to the sea route, and will be considered below.) The climatic barrier here is, of course, the presence of ice. During two to four months in the summer much of the ice melts, and commercial navigation along the coast has been practised for a century and more. Improvements in ship design and strength have led to a large number of ships using these waters, and a longer season. Fifty years of intensive effort have now produced a situation in which navigation in one sector - the south-west Kara Sea - is virtually year-round, but in the other sectors it remains at a few months.<sup>1</sup>

The reason for the Kara Sea activity is the requirement of the nickel mine at Noril'sk to get its ore to the smelter near Murmansk. This success could only be gained by great and sustained effort in many spheres, particularly in the building up of a fleet of icebreakers and strengthened freighters, and in the training of crews to get maximum advantage from them. In both these spheres the Russians have advanced a good deal farther than anyone else. The icebreaker fleet contains three nuclear-powered ships, and also four relatively shallow-draught ships designed specifically for work in estuaries such as that of the Enisei. A class of 20,000 dwt strengthened freighters has been coming out of East German yards for use on the run between Murmansk and Dudinka (the port for Noril'sk), and it is now being supplemented by a new class of the same capacity built in Finland. All these freighters are in the Soviet class ULA, the strongest of six classes of ice-worthiness distinguished in their classification. Other investment is required too: provision must be made for study of ice behaviour and for an ice-forecasting system. (Hydrographic survey, chart-making

1. For a fuller account of operations year by year, see Polar Record passim, and also Inter-Nord; or for one with more historical perspective, Ymer, 1980 p.86-129. Detailed sources are not further quoted in this paper, since much of the information is derived from newspaper and radio reports. A reader requiring more information might find it useful to consult T.E.Armstrong, G.W.Rogers and G.W.Rowley: The Circumpolar North, London, 1978

and navigational aids are also needed, but these are not related to climate.) The cost of mounting shipping operations in winter must be very great, and one must assume that the accounting procedures used do not require the total cost to be recovered from the customer. We are told, however, that the Noril'sk mining enterprise is happy to pay good rates, whatever those may be.

This Kara Sea operation is an excellent example of the overcoming of a climatic barrier to meet a particular need. The fact that it seems to have been done successfully invites the thought that it could be done elsewhere along the Arctic coast if an equally strong need arose; that is certainly an arguable possibility, although the practical difficulties would be greater than in the Kara Sea. One might be tempted to go further, and ask does the fact that it has not been done show that no such need has arisen? This contention, however, does not necessarily follow, since the needed equipment may not yet be available in sufficient quantity. One must note, however, a very significant program for building both ice-breakers and strengthened freighters.

Mention should be made of two most interesting voyages in the central Arctic Ocean. In 1977 the nuclear icebreaker *Arktika* went to the North Pole itself - the first surface vessel ever to do so - and in 1978 the nuclear icebreaker *Sibir'* escorted a freighter along a route north of the island groups. The economic significance of such voyages would lie in their opening up a direct route across the Arctic Ocean, as was indeed the stated objective. These pioneering ventures, however, have not so far been followed up. Again, shortage of equipment may have been the reason for this.

It is relevant to enquire whether there may not be other motives besides purely economic ones behind all these developments. There is an obvious strategic interest in the ability to navigate in ice-filled waters (although the water under the ice is a much more promising medium to master). Ships of the Red Navy must surely use these waters frequently, but no publicity is given to this. Presumably the icebreaker fleet is available to assist naval vessels as well as merchant ships,

and if this is true, a proportion of their cost of construction and operation could be charged to the defence budget.

(b). River transport. The rivers are the essential complement of the sea route, since almost all the regions to be served are accessible only from them, and not direct from the sea ports. Until the achievement of near year-round navigation at sea a few years ago, the rivers had in general a longer navigation season than the sea route and so presented fewer problems. But the lengthening of the season at sea raises the difficulty of keeping the rivers open after freeze-up - not an easy task, since the ice is probably solid from bank to bank (unlike the situation at sea), and depth limitations impose severe constraints on icebreaker design. Another climate-induced problem relates to water depth - the optimum navigation period may coincide with the lowest water levels, and this is extremely hard to counter. Nevertheless there has clearly been success in keeping open the Eniseĭ upstream to Dudinka - again due to the need to take out the nickel ore; though one may note that there have also been difficulties, as in the autumn of 1982 when convoys were held up for over a month. There were also the first signs, in the 1982-83 winter, of successful river operations in winter on the Dudinka-Igarka stretch, using three river and port icebrakers.

None of the other rivers to which the Northern Sea Route affords access has been kept open in this way. Yet there would be much advantage in extending the season on the Ob', which flows through the north-west Siberian oil and gasfield, and of which the estuary must have now become accessible to sea-going ships in winter, since they pass it on the way to the Eniseĭ. There would also be some advantage, but less, in keeping the Lena navigable for longer - interior Yakutia needs better freighting links with the rest of the country. But the sea route to its mouth is not yet operable for more than about three months in the year. None of the other rivers, except perhaps the Kolyma, give access to centres of comparable economic importance. Here, then, we have two cases in which climate is a barrier which has not yet been surmounted; and

in the case of the Ob' system, there must be strong incentives to try to surmount it.

(c). Land transport. Whereas the major problem with water transport is in the design of the vehicles, with land transport, vehicles able to operate in Arctic conditions are in the main available, and the major problems derive from the building and maintenance of the track, whether road or railway. The main climatic barrier is the presence of permafrost, which requires the application of a special code of engineering practice if it is to accept any interference to its natural state. The details of this code are known quite well, but their application is expensive. Attempts to cut corners in order to hold down costs sometimes lead to failures and thus to further expense. Snow clearance may be thought a major problem, but in fact northern Siberia is in general an area of low precipitation.

The overland transport system in the Soviet north is of four kinds: rail, road, winter road, and off-the-road. There are rather few examples of the first two. Railways, the most expensive to build, are used only to provide a southern link for major industrial centres. East of the Urals, two interesting new lines are likely. One of these, already partly completed, is to Urengoĭ, a principal producing centre of the north-west Siberian gasfield, with the possibility of later extension to Dudinka, which is already connected to Noril'sk by a 100 km stretch of railway; the other, still at the planning stage, is to Yakutsk. They provide evidence that the engineering problems involved - in both cases difficult - are addressed with a will when the need is strong enough.

Of year-round roads there are even fewer. The principal one is the Magadan highway, from the Trans-Siberian railway at Never through the Lena and Kolyma valleys to Magadan. There was for long, and may still be, a section in the Lena valley which was not year-round, so the usefulness of the highway as a link with the far north-east may be limited. The scarcity of such roads probably has more to do with the relatively low priority attached to motor transport than to difficulties with the permafrost. The commonest form of road in the Soviet north is the winter road (*avtozimnik*), which is

a levelled but unsurfaced track usable only when the ground is hard. There are many of these, and the network can be extended at minimum cost.

The fourth kind of land transport is that provided by cross-country vehicles. This kind is the exception to the rule enunciated above, that track preparation is the main problem. Here the vehicle requires none. But there has been no significant development of suitable heavy-freight vehicles in the USSR. What there has been is a series of airscrew-driven vehicles, appropriate for use on snow surfaces, but they are relatively small and useful chiefly for passengers.

In the case of land transport, the climatic barrier does not seem to have acted very strongly. Links are forged where they are needed, and the barrier is more frequently economic than climatic. Pleas are often heard for vehicles to be specially designed for northern use, but the fact that this is in the main not done seems to indicate an adequate (though improvable) existing technology. Various extravagant ideas for future extension of the road or rail network are sometimes aired - a railway to Bering Strait, for instance - but it is clear that, whatever the engineering problems, cost would be the controlling factor.

(d). Air transport. A very cold climate offers problems to air transport, but none of them are intractable. Runways can be built on permafrost, snow can be cleared, engines can be started. Ambient temperatures are in any case lower at some flying altitudes in the temperate zone than they ever are on the ground in the Arctic. Two problems are the occurrence of ice fog, a condition brought on by atmospheric pollution in an area of sharp temperature inversion, and of white-out, when snow cover and cloud blend to cause loss of depth perception. But apart from these, which are generally of short duration, it is fair to say that no major barrier is now offered to flying by cold climate.

(e). Pipelines. The USSR's major source of hydrocarbons is in north-west Siberia, and there are two other significant northern sources, in the Viljuĭ basin and the Peċora basin

(the latter west of the Urals). All three call for pipeline transportation of the oil and/or gas, and permafrost areas have to be crossed on several of the required routes. As it happens, oil pipelines have not up to now been required in the continuous permafrost zone, so some of the most exacting engineering problems may have been avoided (hot oil in a buried pipeline will tend to melt the permafrost). But gas pipelines have to cross it, and then move into the discontinuous zone and out into areas with no permafrost, so a range of problems is encountered. Many pipelines have already been completed and additional ones, either following existing major routes or bringing in new producing centres, are under construction. The detailed record of operation of these pipelines is not published, but it is clear that in general terms they all function in the sense that hydrocarbons emerge at the other end. Whatever inefficiencies and failures there may have been, adequate technology appears to have been acquired, although details of construction methods are not well known in the west. It seems reasonable to conclude that oil and gas development is not now significantly held up by inability to build pipelines in areas of severe cold climate.

It would appear, then, that the climatic barrier to transportation in northern Siberia exists, but is far from absolute. It has been surmounted extensively on land, extensively in pipeline technology, to a significant extent at sea, and to a lesser extent on the rivers. Of course there remain some situations in which the barrier would be effectively insurmountable: certain road or rail alignments, for instance; but these could very likely be bypassed, or alternatives found. Perhaps the most difficult problem at present, of those that seem soluble in the foreseeable future, is that of winter navigation on rivers. It is true that a substitute solution has been found in the use of the ice surface for wheeled traffic; but this is of inherently more limited usefulness than successful ship operation would be, since freeze-up and break-up periods do not permit any surface use at all. However, there are now indications that this problem is being addressed on the Enisei.

It should be added that there are some cases where the climate helps rather than hinders. The most important is probably the hardening of swamp surfaces at freeze-up, allowing winter roads to be used across terrain equivalent to Canadian muskeg, which is impassable at other times of the year.

The north Siberian climate as a barrier to operations

(a). Mining. Most of the difficulty relating to mining stems from the transport problem: accessibility. But there are cases in which the mining process itself is subject to interruption or worse for climatic reasons. One of these is opencast gold mining with the aid of dredges. The dredge operates in artificially-made ponds, sifting through the alluvium which is brought up from the bottom of the ponds. When the pond freezes over beyond a certain point, the dredge is not able to operate. No economic way of countering this situation has been found.

Another mining operation strongly subject to climatic influence is offshore oil and gas recovery. Obviously floating ice can seriously damage and perhaps destroy any structure standing on the seabed. In very shallow water a way round has been found in Canada by building artificial islands and drilling from these. It might also be possible, but this has only been done once, experimentally, to drill in the ice-free period and then sink the gathering pipes into the sea floor, so that the equipment would be invulnerable to all but deep scouring by ice. A likely location for offshore hydrocarbons in the Soviet Arctic would be the western and south-western Kara Sea. Either of these methods might be usable there, depending on the exact location. But up to now, the only indications of offshore activity have been of exploration in the Barents Sea, where the problems may not be so severe. Nevertheless, the whole subject of offshore drilling in ice-encumbered waters is one which bristles with unsolved and probably unidentified problems.

There are some ways in which a cold climate and the presence of permafrost actually help mining operations. In a mine in permafrost, for instance, the requirement for pit props is much reduced.

(b). Renewable resources. In general, the climate of the last few millennia has rendered the northlands an unpromising region for plant resources. However, there are exceptions, and on the zoological side there is much less restriction. So although the north will never be one of the great producing areas of the world, it does offer some possibilities at least for local consumption.

It is possible to grow vegetables and other crops at remarkably high latitudes, and the Russians have been leaders in breeding varieties of plant which will resist frost and get maximum benefit from the short but intense growing season. Much of this work was done in the 1920s and 1930s by such botanists as I.G. Eikhfel'd, but large-scale application of these methods was not proceeded with because there were other problems such as soil infertility and water shortage, and also because it proved in the end cheaper (as has been the case in North America) to bring in food from the south. The crop which has been most successful in northern Siberia is grass. Grown on the flood plain of rivers, it has provided fodder for herds of cows and horses. On a smaller scale vegetables such as potatoes are grown by individual householders in the plots by their houses, and tomatoes, radishes and lettuce are grown under glass in home-made greenhouses.

In the field of animal husbandry and fishing, a greater impact has been made. Reindeer and many species of fish are indigenous and therefore fully adapted to the climate. Both are exploited, and the techniques of exploitation have been well known for a long time. Other species have also been introduced, such as the cows and horses just mentioned.

Forestry might be thought a promising line to develop in the northern parts of the boreal forest. But in fact the slow rate of growth of the trees, and their small size when fully grown, makes this uneconomic.

It cannot be said that farming is as successful in the Arctic as it can be in temperate latitudes, but the reasons for this lack of success are only partly climatic. Those that are directly due to the climate have been at least to some extent overcome. Further advances are probably possible,

but may not be economically justifiable.

(c). Building. All construction work in permafrost requires close attention to be paid to the dangers of upsetting the heat balance of the soil, whether by placing a building on it or just by stripping off the overlying vegetation. Even a small change of temperature may convert ice in the soil into water, and thus change a strong material into a weak one. It is not uncommon for buildings to be badly deformed and even to fail completely. The dangers are not so great in the case of traditional log buildings, which have considerable elasticity and can accept some differential movement in the foundations. But the modern apartment blocks going up in many towns require strict adherence to the special techniques which have been developed. The stage now reached is that construction work is normally successful but expensive. Here again improvements are possible, and in this case could be economically most desirable.

The north Siberian climate and the human factor

Having considered the effects of climate on the physical and biological environment, let us now turn to man himself. Comparatively few humans are fully adapted to this climate. The number of native inhabitants of the area was about 450,000 in 1979, out of a total population of perhaps 2,500,000, so immigrants account for over four fifths of the whole. Furthermore, most sorts of economic development will call for skills which may not be present in the native population. So the problem of coping with, or getting used to, the climate is bound to be a real one.

It cannot be denied that severe cold is a deterrent to the labour force. Outdoor work becomes exceedingly uncomfortable, and indoor workers suffer from the restriction on outdoor recreation. Various ways of mitigating these negative factors have been tried or discussed. One is the so-called shift method. The essence of this method is that the workers have their homes and families at some established centre in the south, and are flown in to their place of work in the north for shifts of a few weeks, during which long hours are worked. When the shifts are of months rather than weeks, this is called

the expedition method. Thus at the northern end living accommodation can be very simple, with no need for elaborate social facilities, and substantial economies should accrue. At the same time recreation can take place in a more moderate climate. The method is well suited to certain types of mineral extraction, especially where the ore body is relatively small and the site isolated. In northern Siberia the method has been put to use in several places, notably in the north-west Siberian oil and gasfield. The base in this case is Surgut, a rapidly growing town at lat.  $61^{\circ}\text{N.}$ , and the operating areas are between lat.  $76^{\circ}$  and  $70^{\circ}\text{N.}$  However, the method has also been attacked. This has been done partly on economic grounds (the northern base may gradually expand, and in the end two towns are built instead of one), but also partly on health grounds. The argument here is that the human body should not be exposed to such rapid changes, which do not permit adaptive mechanisms to function properly.

Another way is to bring the south to the north - to build a town with controlled microclimate: a collection of buildings with enclosed and heated walkways between them, and perhaps with a park or recreation area enclosed by a vast translucent dome. There have been many designs for such towns - in the Soviet Union, in Canada (Frobisher) and in Alaska (near Anchorage). But none of the spectacular ones have been built. There has been much argument about whether such isolation from the natural climate is desirable. The economic reason for the settlement being there at all - a mine, say - is going to require the workers to venture out into the open at some point, and this may simply become more difficult and unpleasant.

A third way to try to mitigate the discomfort of living in a severe cold climate is to provide exceptionally warm and well-appointed living accommodation. The intention of doing this has been expressed from time to time, but there seems to be a good deal less than general success in achieving it. It is hard enough to reach the same level of comfort as elsewhere, let alone to exceed it. But if the level of expectation is low (as it is), disappointment is minimised.

It is probably true that improvements in clothes have contributed as much as anything to human comfort in the cold. Man-made fibres closely woven into windproof cloth provide protection while avoiding the weight penalty of the earlier skins and furs. But most important of all is the attitude of mind. Persons used to cold will suffer less than those who are not. The relatively high latitude and the extreme continentality of central regions of the Soviet Union imply that no people on earth have more experience of severe cold than the Russians. Wars - Napoleonic, the Second World War - have demonstrated how Russians have used this experience to defeat their enemies.

But in spite of all this, there are still many situations in which the human frame simply cannot withstand the climate. This is probably the weakest link in the chain. Machines and equipment can be devised which will function in the conditions expected, but there will come a point when the human being in charge can withstand no more. There is of course considerable individual variability, and training and physiological adaptation play an important part. But this is the ultimate determining factor.

The object of this paper has been to look at the Siberian case. But it may be of interest to consider also other parts of the north. Are things substantially different there? Has western technology overcome the climate to a greater extent than Soviet technology? In the area of communications this seems not to be so. Soviet sea and land vehicles perform at least as well as their western counterparts, and they are more numerous. Superior Soviet capacity and performance is nowhere clearer than in the case of icebreakers. There is no reason to think that in resource exploitation the west has found markedly better methods, and much the biggest undertakings, though not necessarily the most efficient, are in the USSR. Perhaps one area in which the West excels is in building warm and comfortable living accommodations: not because the Russians cannot, but because the West has to do this in order to attract labour. It is also true that due to

architects like Ralph Erkine the West has considered more carefully and sympathetically, and taken into account more fully, the specific problems of the northern environment.

#### Conclusion

There can be no doubt as to the importance of the part played by climate in economic development of northern Siberia. But it is ceasing to be the dominant part. Most things can now be done in most places, provided there is the incentive to spend the necessary amount of money. There is still room for advances in technology to make some processes possible, or at least cheaper. But the final barriers are the amount of money available and the endurance of the human frame itself.

Terence ARMSTRONG

## LE CLIMAT COMME ÉLÉMENT DÉTERMINANT DANS LE DÉVELOPPEMENT ÉCONOMIQUE - LE CAS DE LA SIBÉRIE

Cet article concerne le nord de la Sibérie où le climat est d'une extrême sévérité : basses températures atmosphériques, longs hivers, obscurité, pergélisol, glaces flottantes.

### 1. Communications

*Par mer.* Problème des glaces flottantes. Navigation possible presque toute l'année dans la mer de Kara du Sud-Ouest. Utilisation d'un important armement spécial. Les voyages au Pôle et au centre de l'Océan Glacial de 1977 et 1978 n'ont pas eu de suite.

*Par rivière.* Problèmes des glaces flottantes et du manque de profondeur. Succès sur le Iénisséï jusqu'à Doudinka, mais pas ailleurs (Ob', Léna), même là où on aurait pu l'attendre.

*Par terre.* Problème de l'entretien des routes et des chemins plutôt que des véhicules qui sont au point. Voies ferrées : les lignes vers Ourengoi et Iakoutsk en projet peuvent indiquer la solution de problèmes techniques. Les routes représentent de grands frais d'entretien ; elles manquent mais pas pour des raisons climatiques. Les routes d'hiver sont utilisées fréquemment, mais c'est une solution partielle. Cross : véhicules à hélice d'avion.

*Oléoduc, gazoduc.* Problème du pergélisol (disparition ou formation). Succès évident.

*Air.* Problèmes du pergélisol et de l'enlèvement de la neige.

### 2. Mines

Les mines à ciel ouvert ont des problèmes liés au pergélisol et aux glaces flottantes. L'exploitation des hydrocarbures dans les régions côtières souffre des glaces flottantes.

### 3. Ressources renouvelables

L'élevage (surtout des rennes) et la pêche fonctionnent de manière satisfaisante. L'agriculture est possible mais non-rentable.

### 4. Facteurs humains

Les immigrants constituent l'essentiel de la main d'oeuvre. Comment éviter l'effet contraignant du froid ? équipes, micro-climat contrôlé, bon logement, disposition d'esprit.

Le climat n'est plus le facteur dominant. La Sibérie du nord est plus avancée que les autres pays nordiques du point de vue du combat contre le climat.

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Climate as a determining factor  
in economic development

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